On the Dynamical Evolution of a Circumstellar Disk and its Effects on the Growth and Sedimentation of Dust Particles

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It is widely accepted that planet formation starts in a circumstellar disk of gas and dust by collisional coagulation of dust particles into larger objects. Solid particles, at this stage, are strongly coupled to the gas, and their dynamics are governed by the gravitational attraction of the central star and also by their interaction with the nebular gas. This interaction is quite dynamic and varies as the nebula evolves. During the evolution of the nebula, while the physical properties of the gas, such as its density, pressure and temperature, vary with time, the gas-particle interaction manifests itself differently and causes the gas to exert different drag forces on solid particles. This affects the motions of dust grains, their relative velocities, and their sedimentations on the midplane, and will ultimately affect their collision and coagulation to larger objects. In this paper, I discuss the effects of the time evolution of the disk on the coagulation of dust particles at the early stage of planet formation. The time variations of the physical properties of the gas result in the appearance of different structures in a dynamically evolving nebula. Among such structures, regions where the pressure of the gas is locally enhanced are of particular interest. In the vicinity of such regions, the pressure gradients-induced velocity-difference between solids and gas molecules causes solid particles to undergo inward and outward migrations, and accumulate around the pressure enhanced regions. Such accumulation can affect the mutual interactions of solid particles, and may also increase the rates of their collisions and coagulation to larger objects. I will discuss the dynamical evolution of solids around such regions, and the effects that the appearance of such structures will have on the rates of the growth and settling of particles during the structures' life-times. I will also discuss the application of this study to faster formation of small solids, and the timescale issue of the gas-giant planet formation in the core accretion model.